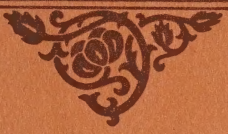
R-4

A STUDY OF VARIOUS TYPES OF BELTING



Compliments of

THE J. C. McLAREN BELTING COMPANY, Limited

MANUFACTURERS OF

Leather Belting and General Mill Supplies

330 BEAUMONT AVE., MONTREAL
50 COLBORNE ST., TORONTO
80 LOMBARD ST., WINNIPEG

R8164.809

Copyright 1919. The Leather Belting Exchange

A Study of Various Types of Belting

BY

ERNEST D. WILSON, B. Sc., Ph. D.

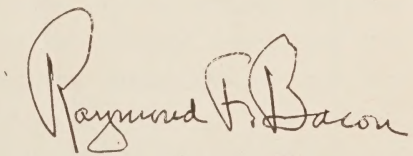
INDUSTRIAL FELLOW OF THE
MELLON INSTITUTE OF INDUSTRIAL RESEARCH
OF THE UNIVERSITY OF PITTSBURGH

THE LEATHER BELTING EXCHANGE
1919

THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH, PITTSBURGH, PA.

PREFACE

The information contained in this pamphlet was obtained during the course of an investigation on power transmission by belting, which is being conducted by the Mellon Institute of Industrial Research of the University of Pittsburgh, for the Leather Belting Exchange. The Mellon Institute through its system of Industrial Fellowships carries on scientific investigations of industrial problems for corporations or associations of manufacturers. The Institute stands behind the work which it does and the experimental results herein have the entire support of the administration of Mellon Institute as to their accuracy and the scientific care with which they have been obtained. Mellon Institute, being an endowed institution, is in an independent position and is entirely unbiased and it is perhaps necessary to say that the Institute, in undertaking an investigation, does not take the position of a lawyer attempting to win the case for his client, but agrees simply to develop the facts by the best methods known to science to-day.



Director.

The Mellon Institute of Industrial Research,
Pittsburgh, Pa.
October 30, 1918.

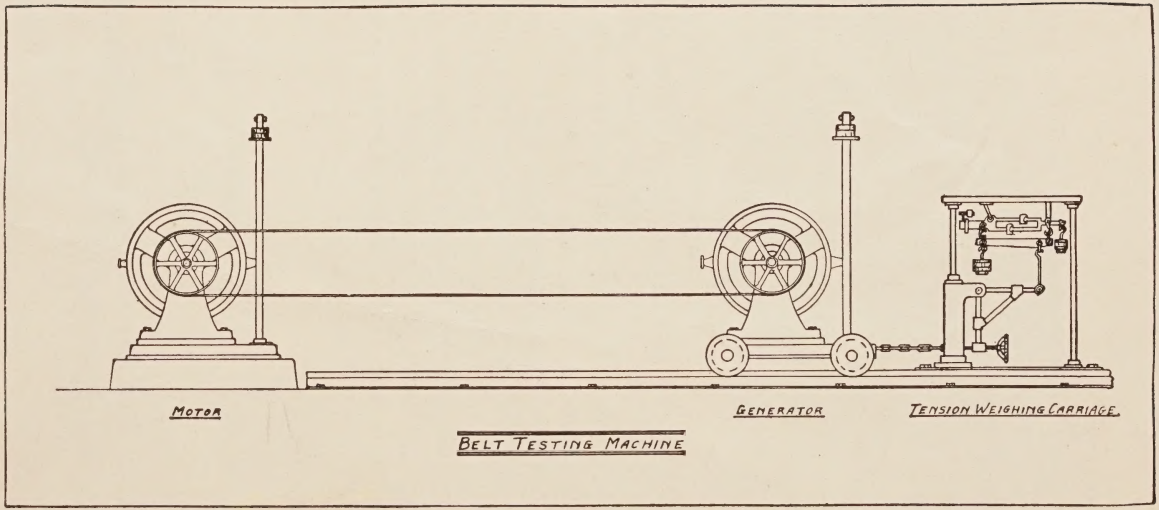

MOTOR
GENERATOR
TENSION WEIGHING CARRIAGE
BELT TESTING MACHINE

Figure 1

A STUDY OF VARIOUS TYPES OF BELTING

ERNEST D. WILSON, B. Sc., Ph. D.

Every one who has had experience in the use of belting for power transmission purposes has in a general way decided upon the relative merits of various types of belts and belt materials. He knows that leather can be relied upon to do certain things, and he has a more or less definite understanding of the limitations of other materials. Naturally, since each drive has its own characteristics and difficulties, there is a lack of agreement among the users of belts as to just what the various types of belting will do, and it was to supply this information that the investigation described later was started.

In the course of this investigation power transmission tests were made on two entirely different belt testing machines at different times, and the results obtained check so closely that all data has been combined and incorporated in this report. Tests were made with various types of pulleys, all of which are in every-day use wherever power is transmitted by belting. While different results were obtained with different pulleys, the ratios between

the various types of belting materials remained the same. That is, although leather on paper pulleys showed higher results than leather on iron, so also did balata and rubber, and the advantage of leather over other materials remained unchanged.

THE BELT-TESTING EQUIPMENT

The three essential parts of the belt-testing machine used for conducting these tests are a motor to furnish the power, a generator to furnish the load, and a device to measure the tension of the belt. The arrangement of these three parts of the machine is shown in outline in Fig. 1. All machinery is of the most approved and latest type, permitting measurements of the higest accuracy to be taken.

Both motor and generator are direct-current machines and are capable of developing 100 H. P. They are known as electric dynamometers, and are manufactured by the Sprague Electric Works. As can be seen from the illustration in Fig. 2, the only difference between one of these machines and an ordinary direct-current motor is that the entire field frame is hung on ball-bearings, so that, when

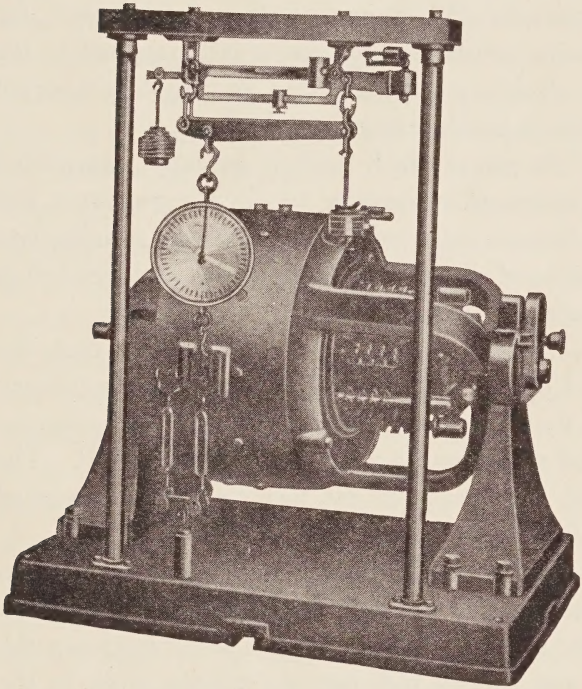


Figure 2

running, the "turning force" which the motor is actually applying to the driving shaft is transferred by levers to a beam-scale, where it can be weighed in pounds. By means of this arrangement for actually measuring the driving force applied to the belt, all theory was eliminated, and the data reported represent purely experimental results.

The power which the belt actually transmitted was measured in the same way by the generator, and the tension under which the belt was running was transferred directly to beam scales and weighed in pounds, as shown in Fig. 1.

The control panel was equipped so that the speed of the motor could be accurately regulated, and the load applied to the belt by the generator varied throughout a wide range of 0-100 H. P. The speed was measured by two electrically operated revolution counters.

In all tests the pulleys used were 24 inches in diameter, some were crowned and some straight face. In the series of tests on the first set of machines the belt was run at 3770 feet per minute, while in the series run on the second set of machines the belt speed was varied from 2500 to 5000 feet per minute. Most of the tests were made at 500 R. P. M., or a belt speed of 3140 feet per minute.

As is well known, the tension under which a belt is run determines to a large extent the power which it will transmit. Naturally, it is desirable to keep the tension as low as possible, both to prevent excessive bearing friction and to avoid unnecessary strains on the belt. In conducting comparative tests on various kinds of belts it is necessary to use the same tension throughout. It was found after a large number of trials that the best method of accomplishing this was to start from the same tension, in all cases, when the belt was running at the desired speed under no load. Tests were made at a number of tensions in order to determine whether or not the relative capacities of the belts changed with changing tension. The light running tension varied from 35 to 75 pounds per inch of width, which corresponds to approximately 45 to 90 pounds per inch of width when the belt is standing still. The difference between the tension of the belt standing still and running under no load is due to centrifugal force. Most of the data here presented are based on tests in which the tension was a little higher than that advised by the manufacturers of the various belts, and ranged from 50 to 70 pounds per inch of width when the belt was standing still.

RESULTS OF BELT TESTS

The tests were conducted by increasing the load on the belt from zero to a point where the slip amounted to at least three per cent. and the belt showed signs of distress. Measurements of speed, tension, and horsepower were made at each step. The horsepower transmitted by the various belts at different percentages of slip is shown in Fig. 3, where the horsepower is plotted against slip.

The curve for leather belting is a very conservative average of a large number of tests. In fact it is almost the minimum curve rather than the average. In the case of the substitute belts, however, the curve shown is that obtained in the *best* test. In the case of the solid woven belting, the curve shown does not take account of the temporary capacity produced by dressing the belt heavily with the sticky dressing sometimes used. Any increased capacity imparted to a belt in this way is not permanent and is a property of the dressing, not of the belt.

These curves show that the fabric belts all possess a very definite maximum beyond which it is impossible to go, and that these points of maximum

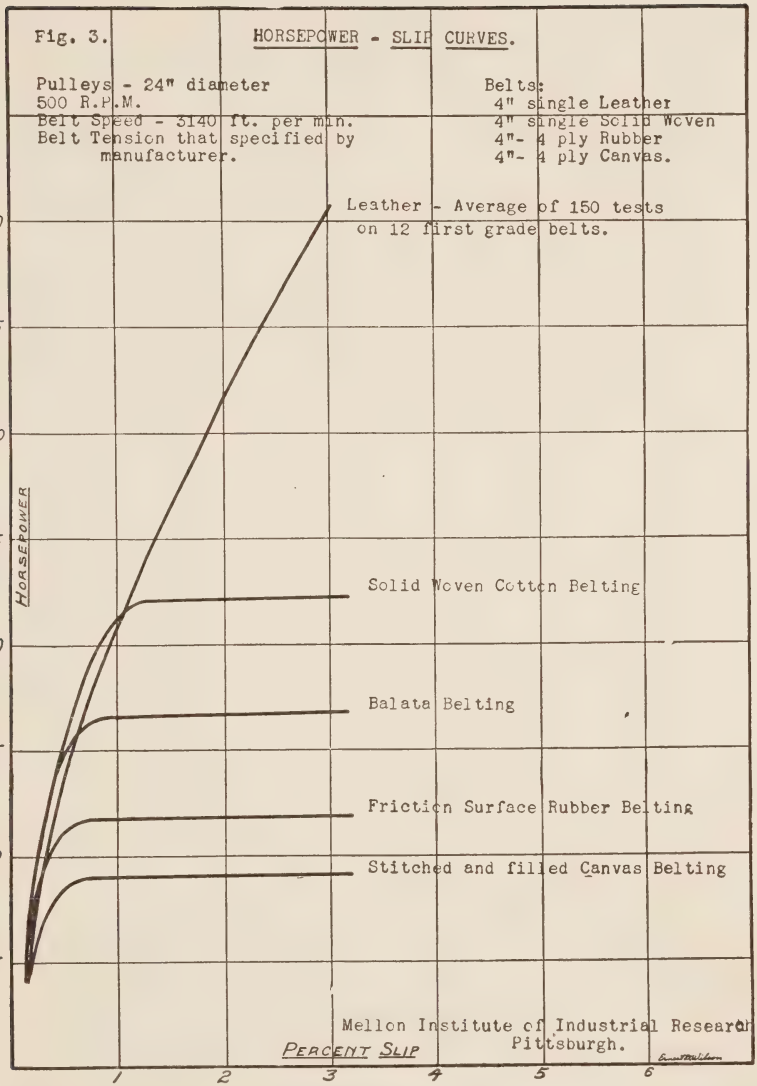


Fig. 3.
HORSEPOWER - SLIP CURVES.
Pulleys - 24" diameter
500 R.P.M.
Belt Speed - 3140 ft. per min.
Belt Tension that specified by manufacturer.
Belts:
4" single Leather
4" single Solid Woven
4"- 4 ply Rubber
4"- 4 ply Canvas.
Leather - Average of 150 tests on 12 first grade belts.
Solid Woven Cotton Belting
Balata Belting
Friction Surface Rubber Belting
Stitched and filled Canvas Belting
HORSEPOWER
40
35
30
25
20
15
10
5
1
2
3
4
5
6
PERCENT SLIP
Mellon Institute of Industrial Research
Pittsburgh.

Figure 3

power-transmitting capacity are below the safe load for leather belting. The leather belts at this speed are rated from 20 to 25 H. P. The curves show that leather belting operating at 25 H. P. has an overload capacity of 60 per cent., while not one of the fabric belts, operating with no factor of safety at all, can carry such a load. While it would not be advisable to operate belts at their full capacities, as shown in Fig. 3, still it is important to know just what margin is available for unforeseen overloads.

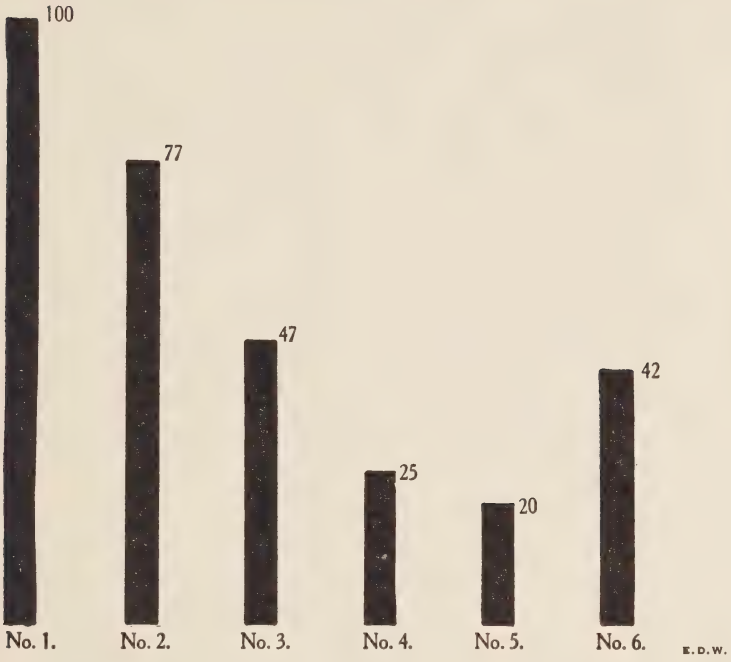
A comparison of the various types of belting may be made in another way which takes account of the tension per square inch cross section of the belt. The relative maximum effective tensions obtained on the basis of 100 for leather are shown in Fig. 4. Since the power which a belt will transmit depends directly on the effective tension it will produce this comparison is very valuable.

The point which is of particular interest, however, is that of the safe power transmitting capacities of the different types of belting under discussion. It must be remembered that each of the substitute belts is sold with the statement, and often the guarantee, that inch for inch it is the equal if not the superior of leather. A careful examination of the curves in Fig. 3 leads to the conclusion that for

LEATHER vs. SUBSTITUTES

Maximum effective pull of belts per square inch cross-section.

Belt speed—3140 feet per minute.



No. 1. Average for first grade, single leather belting.

No. 2. Solid woven cotton belting.

No. 3. Balata belting. Four ply.

No. 4. Friction surface rubber belting. Four ply.

No. 5. Stitched and filled canvas belting. Four ply.

No. 6. Average for the substitute belts.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH.
PITTSBURGH, PA.

this particular drive and four inch belts the horsepower ratings should be as given in Table 1, and from these figures the rest of the table is calculated. The enormous advantage of leather is very apparent, and it must not be forgotten that under these ratings the leather belt has an overload capacity of 60 per cent., while the substitutes have practically none.

Since these tests are entirely comparable with ordinary shop and factory practice they indicate the relative merits of these products. It must be thoroughly understood, however, that for any particular drive it is necessary to use the right belt in order for these comparisons to hold true. The right leather belt for the drive will bear out the above comparisons.

Table 1

	Rated H. P.	Total Lbs. Effective Tension.	Lbs. Effective Tension Per Inch Width.	Feet Per Min. to Give 1 H. P. Per Inch Width.	Comparative Value Leather 100.
Leather	25	270	68	490	100
*Solid Woven	16	175	44	760	65
Balata	12	130	33	1,020	49
Friction Surface Rubber	10	110	28	1,200	41
Stitched Canvas	8	86	22	1,500	32

Note:—The above figures are safe ratings for the various belts for continuous operation on easy drives; i. e. 180° arc of contact, large pulleys, tight side on the bottom and steady load.

* This refers to the heavy fabric belts, impregnated with gums and oils, and not to the lighter White Cotton Belts.

CONCLUSIONS

1. Leather belting possesses a much greater power transmitting capacity than fabric and in the ratios shown in Figs. 3 and 4.

2. The enormous advantage of leather over all the substitute belts persists at all speeds up to at least 5000 feet per minute, and at all tensions within the range practicable for power transmission.

3. The relative capacities of the various belts remain the same on various kinds of pulleys.

4. Leather belting, at its rated horsepower, possesses a big overload capacity, while the fabric belts at much lower horsepower possess no overload capacity whatever.

5. Leather belting improves with age, while the fabric belts are at their best when new.

6. Wherever a fabric belt of a given width is carrying its load with some degree of success, a suitable leather belt three-quarters as wide will do better work than the fabric.

COMPARATIVE VALUE OF DIFFERENT TYPES OF BELTING

LOUIS W. ARNY, Secretary

The Leather Belting Exchange

When belts were first used for the transmission of power a century ago, the only material which seems to have been considered was leather, because leather is peculiarly suitable as a material for Belting. It has great tensile strength; it is tough, and pliable, and flexible, and it is practically indestructible. It has about it none of the elements of decay, and it is not affected by time. There are in existence pieces of leather that are known to be hundreds of years old, still strong, and full of life. Time has no effect on its chemical construction. Water or dampness does not injure it, and it does not rust, or corrode, or crystallize, or disintegrate. It is injuriously affected only by certain acids, and it wears slowly from the results of friction. A leather belt, properly proportioned to its work and of a suitable character, will render service for a long time with reasonable care. There are in use today leather

belts which have been running for more than forty years, transmitting their loads with regularity, and having traveled millions of miles, often at the speed of a mile per minute, and because of this long life, the cost of transmitting power by means of leather belting is reduced to a ridiculously small charge per horsepower per annum.

Waterproof Leather Belts are now made in which the joints are cemented with a material that is not soluble in water, and this belt has the same qualities of durability and permanence for wet conditions as for dry. Water has no effect on either the leather or cement.

The life of a leather belt depends upon the good judgment with which the belt is selected for its work, and the care which it receives. A leather belt requires very little attention in service, but it requires some. It should be clean, and if the ends are not lapped, the lacing or other connection should be kept in order that the ends may be kept perfectly square with each other; any little defects which may develop at the joints should be promptly repaired, and the belt should be dressed occasionally with a good belt dressing, taking care to avoid injurious preparations. Nearly all of the deterioration which occurs in the fibre of the leather can be traced to

the injurious character of the dressing, or to the excessive quantities which have been used. Abuse and neglect are therefore the principal enemies of the leather belt, and where these are eliminated a long life may be expected from any suitable leather belt on a well designed drive.

Leather belts are easily cared for. Where possible they should be made endless on the pulleys. A new endless belt will require to be tightened a couple times, but this is a small job, and then the belt will run for a long time with no other attention than occasionally cleaning and dressing it. If there are lacings or hooks that have injured the ends of a belt, new pieces may be cemented on them and there need never be more than one joint in the belt. Should the belt outlast its first installation, it may be cut to a narrower size, may be shortened or lengthened by any practical mechanic, and the remodelled belt is as good as ever for another place. If it is a wide belt it can be cut into several sizes, or if insufficient in size, an additional ply may be built upon it.

When it has become an old belt, and is beyond the repairing ability of the mechanic of the shop, it can be rebuilt by its maker, the bad places cut out, the good retained, and sufficient new added to make the proper length. It is then good for many

more years of usefulness. Or, if there is no place for it in the shop which has owned it, there is a ready market for it as a second-hand belt at a good price. When, in its extreme old age, repairs become inadvisable, it still has a value for use in repairing other old belts, or for straps, brake shoes, heel taps, &c. The last remnant of it is worth something to somebody.

It will be observed that none of these statements is true of those belts which are used as substitutes for leather belts. The preceding pages show conclusively that they will not transmit as much power; and experience has demonstrated that even under the smaller loads of which they are capable their lives are but a small fraction of that of the leather belt; they cannot be made endless in a practical way, and when so made the joints cannot be opened and cemented together again by the shop mechanic. These ends then must be joined by metallic or leather fastenings, which are not permanent, and which soon destroy the fabric of the ends of the belts, so that it usually becomes necessary to insert other pieces of the belt to make the length, doubling the number of joints and the probability of trouble from them. These belts cannot be run where the belt may be chafed on the edges, and they cannot be cut down

into other sizes, or repaired or rebuilt, and when they finally are discarded, they have no salvage value, but must be cast upon the dump.

Some of these belts have a low first cost; others of them approximate the cost of the leather belt, but all of them, calculated on a basis of the cost of transmission per horsepower per annum, will be found to cost many times the price of the best leather belts.

ALLEN, LANE & SCOTT, PRINTERS